The COMMUNICATION RECEIVER

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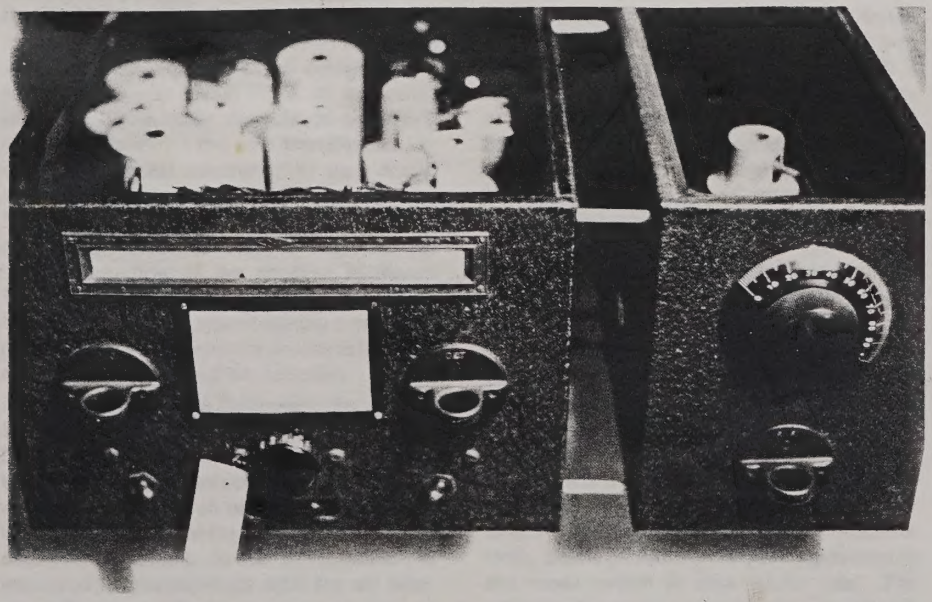
TYPE H.R.O. RECEIVER



THE REMARKABLE FB-7 RECEIVER

By 1932 the National Company of Malden, Massachusetts, was already an established name in the short-wave receiver and components market as a result of a broad line of well-known and excellent products. Starting with the Thrill Boxes of the late 20's, progressing to the widely used SW-3 from 1931, and then with the superb AGS superhet in 1932, National products were exemplified by a high quality of design and manufacture. Average Joe Ham, unfortunately, could not afford the AGS, which was developed for the Bureau of Air Commerce, and continued to use either his home-brew regenerative squealer or one of the lower-priced manufactured sets such as the SW-3.

But the bands were becoming more crowded with the increase in amateur activity in the early 1930's, and Joe Ham wanted to participate in the advances in technology. The commercial interests were also looking for an economical and dependable receiver, preferably using the superhet circuit which had already been around for several years and which was demonstrably superior. The time had come for a communications superhet which both groups could afford and identify with; the depression.

There was a market, and the Comet Pro introduced by Hammarlund in April 1932 became widely recognized in a few months as an excellent performer, and for a time seemed to be the only game in town. National attempted to compete by offering the AGS to the amateur ranks in October 1932, but it was too expensive and not many were sold.

In the meantime, however, the elements were to result in the FB-7 were rapidly coming together. Chief among these was a quartz crystal IF filter, invented and patented by James Lamb, the Technical Editor of *QST*. In a series of landmark articles beginning in June 1932 [1], he described the faults of the existing CW receivers and offered as a remedy the concept of "*single-signal*" reception based on the use of his filter. James Millen, in charge of engineering at National, brought to the picture a considerable experience and expertise in the design and construction of communications receivers, and significantly, the commercial rights to the use of the Lamb filter. W6SAI has reviewed the sequence of events [2]; it makes excellent reading.

Lamb then proceeded to give details on how to build a single-signal receiver in the August and September 1932 issues of *QST* [3, 4]. Three new tubes had just been announced ... the 56, 57, and 58 ... and he took advantage of the 58 with its unusual construction and a 3rd grid brought out to a separate base pin. Wasting no time, the National Company offered – both direct and through dealers such as M&H Sporting Goods in Philadelphia – a kit of "*special parts*" for the "*new ultra-selective single-signal high frequency receiver*". The cost was $80.

In March 1933, Lamb capped his work by describing the alignment procedure for the SSS. It is interesting to retrace history by reading the series of articles. And in the same issue, two new receivers made their debut. The HAM SUPER, by McMurdo Silver, late of Silver-Marshall, featured plug-in coil drawers with both general coverage and band spread provisions, a built in power supply, and simple controls with single-dial tuning. It was however, completely overshadowed by the FB-7.

Millen, clearly demonstrating his style, had produced a winner. Designed around the Lamb filter (but a good performer even without the filter), and using parts from previous National receivers, he presented to the amateur and commercial users a simple, well-engineered superheterodyne, not a kit, with advanced design features and selling for the extremely low net price of $33. Not included in the price, but separately available, were the Lamb filter (the cabinet was already punched and drilled for the unit), an outboard National power pack, and coils for bands other than the one chosen by the purchaser. To the amateur, this "*add-on*" concept was important. Joe Ham looked at the receiver, trusted to his resources to pick up the tubes and power it up, and he bought.

The FB-7 had single dial tuning with frequency calibration charts mounted on the panel, a calibrated gain control for an approximate measure of signal strength, and the convenience of front-of-panel coil changing as used in the AGS. There was no output transformer, the user being expected to use the then common high impedance electro-magnetic speaker. Coils were available for the 160, 80, 40, and 20 meter amateur bands. Each ham band occupied 100 divisions on the dial, a good illustration of the machining precision used by National in manufacturing the tuned circuit components. In August the 10 meter coils were offered (FB-AA ... 19-31 MC), extending the total range from 1500 to 33,000 kc.

The marketing and advertising program for the new receiver was superb. A dealer network was in place, and the excellent ads and articles in *QST* and other trade journals [5] kept up an constant barrage of messages using the new terminology and emphasizing reliability, performance, new features, and low price combined with the latest in communications technology. The buzz words of the day included such hyphenated adjectives as "*single-signal*", "*drift-free*", and "*true-tracking*" ... the last based upon the use of air variable trimmer condensers mounted inside the coils. The message to the amateur was that he could, with limited financial resources, buy the basic FB-7 receiver, and in due course add the filter, buy other coils to expand coverage, and perhaps invest in one of the National power units as his finances permitted. But from the first, he would have a basic communications superhet which gave him a stability and selectivity not previously available for such a low price.

The finished receiver was hardly a thing of beauty, being housed in a black sheet metal box 11½" x 12" x 8", and with the controls and switches unmarked. The SE tuning capacitor came from the SW-3, and the slide-rule dial was a standard VK unit with the scale modified to 1-150 divisions and which had been used in the SW-58. The coils and mounts were the same as those used in the AGS, the forms moulded from R-39 material and with the unique National 6 pin basing pattern. The 500 kc IFs were also from the AGS; on review, one gets the impression that the only really new components were the cabinet, and of course, the Lamb filter in the FBX version. Millen and his group, by the way, had already taken the position with the AGS and SW-3 receivers that design parameters for

[Continued on next page]

serious communications receivers included separate power packs and plug-in coils, and in spite of market pressures to the contrary, National stuck to this philosophy with both the FB and HRO receivers. More on this subject later.

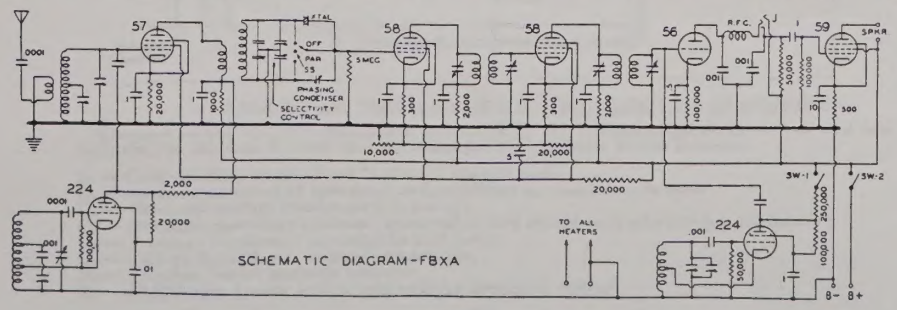
Changes appeared quite rapidly. Within one month, possibly stimulated by the Hammarlund activity, National presented in a full page ad in *QST* their version of an air dielectric tuned IF transformer which could be used as a replacement in the FB-7, or any other receiver. Production models of the FB-7 which incorporated the new transformer (or one which closely resembled it) were designated the FB-7A, and the receivers with the filter as the FBX and the FBXA. All four models were available to the market from the first introduction of the receiver in March 1933, and with so much subject matter to cover in the ads it appeared simply a matter of presenting the story and the products in some sort of logical, phased introduction.

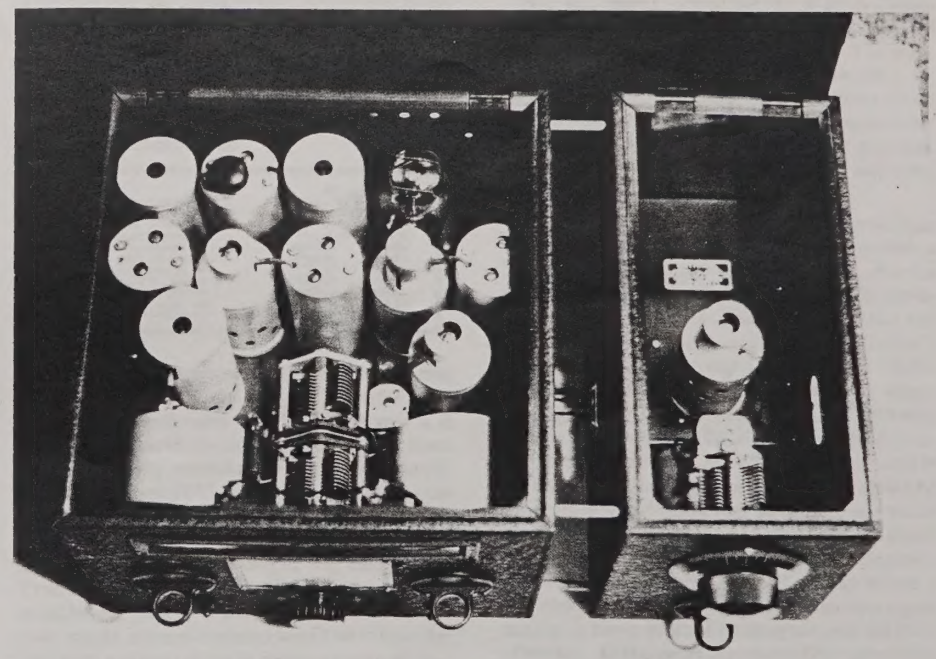
It is relatively easy to distinguish the original from the "A" versions. The former had the Lizendraht IF transformers with compression trimmers; the condenser adjustment holes were close together on one side of the round IF cans and straddled the point of the National diamond trademark. In the "A" models, the improved IF transformers with the air trimmers, had the adjustment screw holes on opposite sides of the top of the IF cans, 180° apart. Incidentally, regarding price, in January 1934 the FB-7A was advertised by one dealer for $34.20, and the FBXA for $47.40.

Of interest is the layout of the crystal filter, an exact duplicate of the original Lamb design with a three position control switch. With the switch in the up position, the filter is OFF and acts as a conventional IF transformer and when the switch is moved to the center of PARALLEL mode, the filter acts as a trap to reject an IF signal tuned exactly to its frequency. In this position, an interfering heterodyne could be separated out. When the switch was down, the filter was placed in the single-signal or SERIES mode. Later filters, such as those used in the HRO, simplified the controls. The original crystal units were supplied by Bliley; they resembled a flat, black pill box with a screw-off top.

Joe Ham quickly noted that the image problem with this receiver, lacking an RF preselector, was particularly bothersome on 7 and 14 mc, especially the latter. The problem, not being limited to the FB-7, prompted Lamb and Handy to do something about it. Their solution, a preselector-amplifier[6] could be used with the FB-7, the Comet Pro, and any similar receivers. Conveniently for National, their parts were used, and the *QST* article showed the unit attached to the side of an FB-7, as Orr says [2], "*like a wart on a dill pickle*".

Within 60 days, National had the PSK Preselector on the market. In addition to image suppression, other claims for the unit included improved weak-signal response, improved signal-to-noise ratio, and increased sensitivity. The size was 6" x 8" x 12", and it could be fastened to the FB-7 with a 1½" space between to allow access to the single-signal controls. Some pictures show a lever attached to the mode switch to allow easier use. The authors also recommended replacing the 57 first detector with a 58 to reduce cross modulation; the gain from the preselector more than made up for the loss in gain caused by the change. The arrangement did work, and the overall performance on 20 meters was considerably improved. The combination, however, took up more room on the operating table than the HRO which succeeded it. Another approach involved using the SW-3 receiver as a preselector [7]. If the *QST* is not available, details can be found in two articles in the September 1982 and March 1983





Top view of FB7X. The pre-selector is at right.

issues of the *OTB*.

Joe Ham, in the meantime, decided to invest in more coils (he wanted to sample the other frequencies and he liked the precise calibrations), a National-built power supply with the heavier filament winding which gave the correct voltage at the tube sockets (for some reason it seemed to work better than the home-brew power pack taken from that old BC receiver), the single-signal Lamb quartz crystal filter (you only live once, and what is all this single-signal stuff?), and finally, the PSK preselector which was a necessity for satisfactory 20 meter operation.

Predictably, Millen mentioned in August 1934 that a totally new receiver would debut in the fall ... it would sell for around $200, and have lots of new features. Price continued to be a factor, however, for many hams, and even after the formal announcement of the HRO in October 1934, the FBXA was available at a net price of $51.95, "*the answer to hard times*".

By 1937, the receiver had virtually disappeared from published pictures of amateur and commercial stations, being replaced by, among others, the HRO, the RME 69, and the various Super Skyriders. It is not known how many were actually produced or how many preselectors were made. The PSKs are rarely seen and both are sought after collector items.

Because of widespread interest in this receiver, additional information on the coils, preselector, power supplies, and renovating and aligning it for use will be given in the next column.

-- Bill Fizette, K3ZJW

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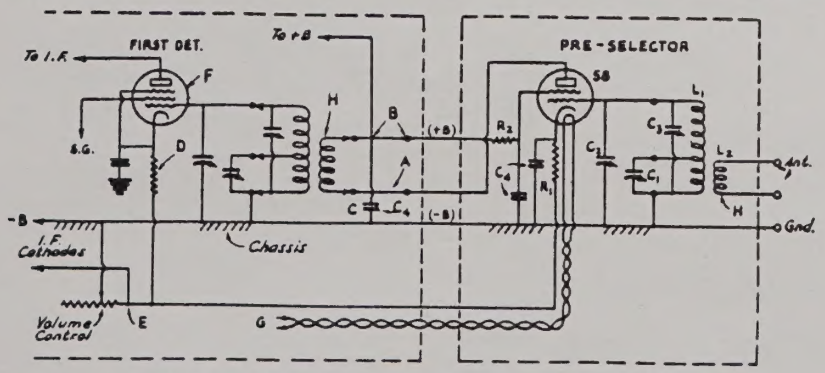
THE REMARKABLE FB-7 RECEIVER

Part II

Joe Ham acquired one of the new FB-7's late in 1933 and proceeded to use it on 80 meters. In due course he moved to the 160 and 40 meter bands, and finally, with activity increasing on 20, purchased the coils to take the next step. At that point he ran headlong into the image problem characteristic of receivers without a preselector or RF stage. The Lamb-Handy preselector, detailed in *QST* for December, 1933 [1], was the answer. The tuning was sharp, no signal strength was lost, and images were substantially reduced.

The unit was assembled using standard National components. The coils were FB-7 detector coil assemblies plugged into a standard Type XC coil shield mounted in a 2" hole on the front panel. Changes made in the FB-7 to incorporate the preselector into the circuit included feeding the B+ through the original antenna coil, lowering the detector cathode resistor from 20,000 to 2500 ohms, adding gain control to the pre-selector and the first detector stage. The primary windings of the preselector and first detector coils were modified to reduce coupling, resulting in sharpened selectivity and improved signal gain. Capacity coupling from the antenna, mentioned as a prime source of image input to the receiver, could also be minimized by the addition of a Faraday shield (for electrostatic shielding) placed between the antenna input coil and the receiver input circuit. A several-hundred per cent reduction in image response was claimed.

Once the receiver had established itself in the market place, National proceeded to promote the accessories. The coils were undoubtedly a large source of sales dollars, since they were almost impossible to duplicate using otherwise standard components of the day. Including the 10 meter coil set which came along in a few months, and with the preselector in the circuit, the FB-7 owner could have potentially 11 sets of 3 coils each, or 33 coils in all. At $5 each ($3 amateur net), the investment in a complete set ranging from 800 kc to 34,000 kc continuous coverage, with bandspread coils for 160/80/40/20 meter bands was considerably more than in the original receiver. Originally developed for the AGS receiver, they were wound on threaded forms of R-39 and protected by an outside fiber sleeve. A cast handle, which also acted as a front shield, and an internal adjustable air condenser in the oscillator coil completed the assembly. The attached listing of coils and the calibration charts are taken from National's Bulletin #220.



CIRCUIT OF THE ONE-STAGE PRE-SELECTOR AMPLIFIER

Changes in the receiver circuit are indicated by the alphabetical designations and are described in the text. Circuit specifications for the addition are as follows:

L_1 — *Grid winding of standard National plug-in coil.*
L_2 — *Antenna winding of standard coil, modified as described in text.*
C_1 — *100-μμfd. midget condenser (on panel).*
C_2 — *100-μμfd. auxiliary trimmer (external to coil shield and set once for all bands).*
C_3 — *Trimmer condenser mounted in coil form.*
C_4 — *0.01- to 0.1-μfd. r.f. by-pass condensers.*
R_1 — *300-ohm 1-watt cathode resistor.*
R_2 — *50,000-ohm 1-watt screen-grid voltage dropping resistor.*

Catalog No.		Range
AB 20	(air padded osc.)	20 Meter Band Spread
AB 40	(air padded osc.)	40 Meter Band Spread
AB 80	(air padded osc.)	80 Meter Band Spread
AB 160	(air padded osc.)	160 Meter Band Spread
FB AA	(air padded osc.)	34000 to 18000Kc
FB A	(air padded osc.)	19500 to 11400Kc
FB B	(air padded osc.)	11700 to 7000 Kc
FB C	(air padded osc.)	7300 to 4000 Kc
FB D	(air padded osc.)	4200 to 2400 Kc
FB E	(air padded osc.)	2500 to 1500 Kc
FB F	(air padded osc.)	1500 to 900 Kc

Joe Ham was given several options for powering the FB-7. If he already had the National Type 5880 supply which came with the SW-3 receiver, it could be used even though the filtering was more than was actually needed for the FB-7. Also available was the Type 5887 low-priced supply (note the continuing price emphasis), which gave 180 volts of B under load and could deliver up to 1½ watts of audio. When full audio output was desired, the Type 5897 AB pack, giving 240 volts under load, could be purchased. If batteries were used for the plate supply, the requirements were 180 volts under load with a current drain of approximately 40 ma.

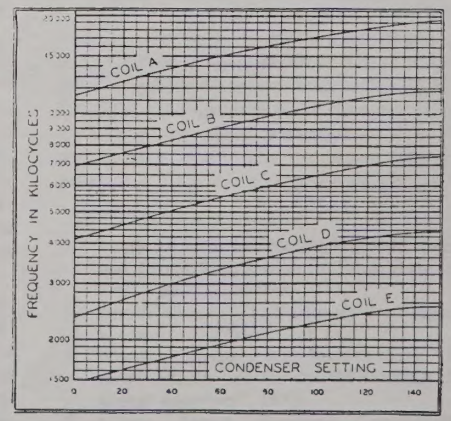
Since the power supply was on a separate chassis, Joe also had the choice of building his own. However, the heater circuits drew 9½ amperes, and with a drop in the power cable of approximately 0.3 volts, the source had to provide 2.8 volts to give the required 2.5 volts at the tube sockets. The National engineers strongly emphasized, for both the FB-7 and the early HRO receivers, that erratic and unsatisfactory operation would result if the heater voltage dropped below 2.25 volts.

Restoring the FB-7 to operational status is not too difficult if some care is exercised. A good cleaning followed by a shot of lubricant on all the controls is first. If the tuning capacitor binds, Orr [2] suggests loosening the mounting screws and moving it to the best position. Pay close attention to the wire-wound gain control; the one on the writer's FB-7 opened up during a QSO. Check all resistors for proper value and the capacitors, especially the bathtubs, for leakage. Remarkably, the capacitors and resistors on the two FB-7s the writer has checked were all good. Examine the IFs carefully for signs of abuse, and check all grounds to see that they are still good. When the sets were built the grounds were simply lugs with star washers riveted directly to the painted chassis, and corrosion and rust may have built up resistance points. Be sure to clean the tube and coil pins and associated socket connections by using cleaner and moving them back and forth. Remember that the DET coil is on the right and the OSC on the left when facing the set.

National recommended the use of RCA Radiotrons in an effort to remove the variables associated with the use of various makes of tubes. The argument was that the demands of high frequency receivers were more exacting, and that tubes which worked fine in BC receivers would not necessarily perform properly in the FB-7. W6SAI mentions that some of the 24A's are microphonic, and some experimenting may be in order.

Alignment of the IF circuits in the sets without the crystal filter consists simply of peaking them at 500 kc with an accurate signal generator. For the FBX and FBXA models the procedure is somewhat more complex [3]. Remove the crystal and peak the IFs somewhere close to 50 kc (within 5 kc). Reinstall the crystal and place the crystal selector switch in the series position for single signal reception. Set the selectivity control for max selectivity. The edge of knurled disk is moved as far as it will go towards the rear of the receiver. Tune in a steady carrier and by tuning across the signal find the point where it peaks very sharply. Next adjust the phasing or balancing condenser until the signal is weakest. To check the action of the selectivity control, leave the receiver tuned exactly where it was and rotate the control disk to the loudest signal setting, at about ⅔ of the rotation towards the front of the set. At this point the crystal filter selectivity is at a minimum. Reset the filter to maximum selectivity and do the final adjustment of the IFs.

Next, check the crystal activity (with the set still at maximum selectivity) by moving the selector switch from the single signal (central) position to the straight superhet position; there will be an increase in noise but no change in the signal strength. Resetting the selectivity control will give an increase in signal strength; this is normal. If the crystal is a poor resonator, it should be cleaned and the air gap checked to see that the crystal is free between the plates. The air gap is usually 2 or 3/1000".



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TESLA PIONEER IN DEVELOPING RF ALTERNATOR

The work of independent inventors is always done in secret to protect their financial interests. Historical research on the work and accomplishments of these non-industrial inventors is therefore most difficult. The spectacular Nikola Tesla, who during his entire career undertook research in his own laboratories, designed and constructed high-speed, high-frequency alternators with outputs not equaled by Alexanderson and Fessenden until 15 years later.

According to Leland Anderson, who is working on a technical paper and book including the work of Tesla on this subject, the alternator that Tesla used in his first (1891) lecture on high-frequency currents produced 30 amps at 20,000 cps. Another alternator constructed later that year had an internal resistance 1/40 ohm and produced 160,000 cps at 20,000 rpm. The Tesla Museum will soon publish a six-volume set of Tesla's writings and notes that will undoubtedly upset some popular notions of priority for a number of radio developments, says Anderson.

THE REMARKABLE FB-7 RECEIVER (Continued)

To adjust the coils in accord with the calibration curves, first set the tuning dial to 120, the frequency generator to the high edge of the band, and tune the oscillator coil trimmer. If two settings are found, use the higher. Next, move the tuning dial to 20 and change the signal source to the low end of the band, remembering to use the band edges of 1933. The signal should be (at least it should have been there in 1933) within 2-3 dial divisions. The detector trimmer condenser mounted on the right side of the tuning gang inside of the cabinet is used for aligning the general coverage coils.

For the output, hook up either a 6000 ohm output transformer and matching speaker or one of the 1933 vintage high impedance types; if phones only use is contemplated, pull the output tube unless the plate circuit is completed. To avoid overloading the front end and generating spurious signals within the set, couple the antenna (preferably short) as loosely as possible. Use an isolating capacitor, or better still form of outboard tuned coupling circuit.

If you use a home-built power supply, be sure to measure the filament voltages at the set using an accurate meter. A separate filament transformer of at least 2.8 V at 10 amps is recommended; if such is not available, one can be wound on an old transformer core with a good primary (shades of 1933). If one of the original National power packs is employed, it is a good idea to replace the electrolytics with fresh cartridge types, leaving the old cans in place for appearance.

Another approach to putting the FB-7 on the air is to change the tubes to the 6 volt equivalents of the era. The 56, 57, and the 58s can be replaced by a 37, a 77, and 78s; the 24s by 36s. The writer has used this method successfully. A suitable direct replacement for the 59 was not found and it was removed and phones were used. However, it should not be too difficult to use either an 89 or one of the later common octal based outputs with an adapter. By the way, don't forget to change the 2½ V pilot lamps.

It is often difficult to find extra coils, but if the National XR-39 forms are available, they can be wound if care is used. While it would be difficult to precisely duplicate the unique AGS/FB-7 cover plate casting, a functional substitute can be fabricated from Al sheet stock and a drawer pull.

There has been considerable discussion over the years regarding the origin and significance of the term "FB-7", the name of the receiver. The "7" referred to the number of tubes in the set proper, while the "FB" came from the initials of a secretary at the National Company, Frances Bearse, who later joined Jim Millen as one of the charter members of the James Millen Manufacturing Company [4].

Finally, some sharp eyed readers have by now noted that the caption under the photo on page 17 of the September *OTB* is incorrect; it is, of course, an FB-7A, without the crystal filter, not the FBX. And for those who wondered at the strange sentence at the end of the second paragraph on page 14, it should have read, "The depression was in full swing, and price was clearly a consideration".

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4. Millen, James, Personal Communication, August, 1985.

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